BULLETIN OF MARINE SCIENCE, 70(1): 211–216, 2002

SIZE STRUCTURE OF GRAY SNAPPER (*LUTJANUS GRISEUS*) WITHIN A MANGROVE 'NO-TAKE' SANCTUARY

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The establishment of marine reserves has been offered as an important fishery-management tool to complement the more traditional methods of size and bag limits, gear restrictions, closed seasons, and limitations on the number of fishers. In several parts of the world, 'no-take' zones, areas where fishing is forbidden, have been shown to benefit exploited populations, critical habitats, and community structure (see studies listed in NRC, 1999). Because fishing and bycatch mortality are all but eliminated in no-take areas, fish within these zones should live longer, grow larger, and be more fecund than those in fished areas (PDT, 1990; Bohnsack, 1993). Despite these expected benefits, the creation of marine protected areas in U.S. waters is relatively new, and where they have been established, they have been small in scale (Ogden, 1997; Murray et al., 1999). Consequently, there are few examples of no-take zones in the U.S. that can be used to evaluate their true benefits for exploited marine species. While the scientific community has largely embraced the use of marine reserves in fisheries management[1], detractors, mostly sport fishermen, continue to point to the lack of evidence that expected benefits will actually materialize (Law, 1996; Parrish, 1999; Lydecker, 2000; Wickstrom, 2000a,b).

Size-distribution data can be a useful tool to assess the effectiveness of no-take reserves. The shape of length-frequency distributions is a result of recruitment, growth, mortality, and sampling (MacDonald, 1987). If sampling bias is comparable, a species' length-frequency distribution from different areas can yield important biological information specific to a given location. Since fishing mortality is selective towards larger fish and will be greater in fished areas than no-take zones, areas free of fishing mortality would be expected to contain more large individuals.

Here, we report length-frequency patterns observed from an ongoing study designed to examine fish utilization of red mangrove (*Rhizophora mangle*) shorelines in southeastern Florida. In this effort, differences in the size structure of gray snapper (*Lutjanus griseus*), a species that is considered overexploited in this region (Ault et al., 1998), were revealed between an area closed to fishing and in surrounding waters open to recreational fishing.

Methods

Study Area.—With a focus on southern Biscayne Bay, Card Sound, Barnes Sound, and northeastern Florida Bay (Fig. 1), the present study was conducted within and adjacent to Biscayne National Park (BNP), Everglades National Park (ENP), and the Florida Keys National Marine Sanctuary (FKNMS). Established in 1980, 1947, and 1990, respectively, BNP, ENP and FKNMS together encompass an area of approximately 15,475 km^2 that includes offshore coral reefs and extensive seagrass, hardbottom, and mangrove habitats inshore. Despite their respective national park and 'sanctuary' designations, fishing is permitted within the vast majority of BNP, ENP and FKNMS waters. There is one area however, where public access, and therefore fishing, has been

[1] see studies listed in *Bulletin of Marine Science* 66(3).

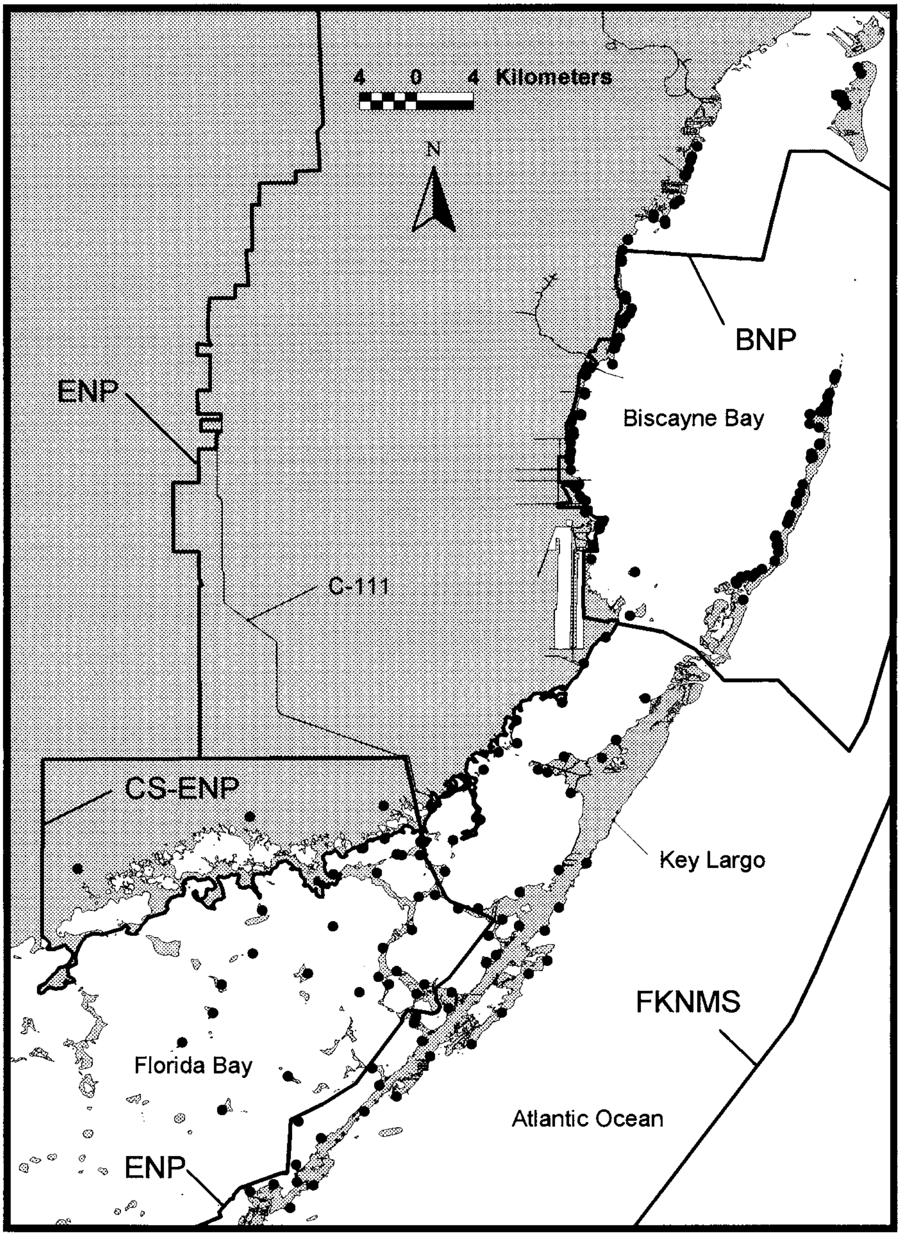

Figure 1. Map of southeastern Florida, depicting visual survey locations, the C-111 canal, and various park boundaries: Biscayne National Park (BNP), Everglades National Park (ENP), the Crocodile Sanctuary of Everglades National Park (CS-ENP), and the Florida Keys National Marine Sanctuary (FKNMS). Each point shown within the CS-ENP represents four permanent survey locations.

forbidden since 1980 (Fig. 1). The Crocodile Sanctuary of Everglades National Park (CS-ENP) was established to eliminate the adverse effects of human intrusion and boat use on the endangered American crocodile (*Crocodylus acutus*) (ENP, 1992). The CS-ENP encompasses approximately 33 km^2 of aquatic habitat (i.e., mangrove-lined creeks, marshes, and embayments) that supports several recreational fishery species including *L. griseus*, common snook (*Centropomus undecimalis*), tarpon (*Megalops atlanticus*) and spotted seatrout (*Cynoscion nebulosus*). The CS-ENP is also frequented seasonally by the endangered West Indian manatee (*Trichechus manatus*), numerous wading bird species, the American alligator (*Alligator mississippiensis*), and several species of shark (Lorenz, 2000; pers. observ.).

Data Collection and Analysis.—Size information for *L. griseus* was obtained as part of an ongoing visual census study designed to examine fish utilization of the mangrove-lined shorelines of Biscayne Bay, Florida Bay, and the two sounds connecting them (Card Sound and Barnes Sound). Fishes were quantified using modifications of the belt transect method of Rooker and Dennis (1991) and the timed stationary-count method of Ley et al. (1999). All visual censuses were conducted between 09:00 and 17:00 to minimize problems of low light and twilight changeover. Prior to conducting censuses, observers were trained to accurately estimate fish length following Bell et al. (1985); total lengths (TL) were estimated to the nearest 2.54 cm (= 1 in). Length-frequency (percent) distributions with 5-cm intervals were constructed for Biscayne Bay (fished), the CS-ENP (not fished) and northeastern Florida Bay (fished) by applying the technique used by Ault et al. (1998), which was fully detailed by Meester et al. (1999). Length-frequency distributions were referenced to the 25.4 cm TL minimum legal size for *L. griseus* that was implemented by the State of Florida in 1990. Pair-wise comparisons of the percentage of legal and sub-legal sized fish among regions was made using chi-square analysis.

Results and Discussion

We examined length data from 438 visual fish censuses conducted between September 1996 and March 2000. The number of censuses conducted in Biscayne Bay, the CS-ENP and northeastern Florida Bay was 129, 228 and 81, respectively. The total number of *L. griseus* observed was 1,824 in Biscayne Bay, 1,485 in the CS-ENP and 1,317 in northeastern Florida Bay. Here, we refrain from making density comparisons among the areas examined, because fish-enumeration methodologies were not identical for all censuses.

Length-frequency distributions for *L. griseus* in the three areas examined were each unimodal, but differentially skewed about their respective modes (Fig. 2). The modal size class for fish in Biscayne and northeastern Florida Bays was below the minimum legal size at 15–20 cm TL. In contrast, the modal length for fish in the CS-ENP, where fishing has been prohibited for over 20 yrs, was two size-classes larger at 25–30 cm TL. Differences in the percentage of legal-sized individuals (i.e., >25.4 cm TL) among areas were also apparent and very highly significant ($P<0.001$): the percentage of legal-sized fish was 15.6% in Biscayne Bay, 66.2% in the CS-ENP and 29.6% in Florida Bay. A similar pattern to ours appears in visual census data collected by Ley et al. (1999). They censused monthly at eight stations within the CS-ENP and 16 stations in northeastern Florida Bay during 1989 and 1990. Ley et al. (unpublished data) found: (1) mean TL of *L. griseus* was 26 cm within the CS-ENP versus 22 cm TL outside this area; and (2) percentages of legal-sized fish were 53.5% in the CS-ENP, compared to 35.2% in adjacent, open-access areas. Collectively, these size-structure differences between the unfished CS-ENP and the fished areas to its north (Biscayne Bay) and south (Florida Bay) are strongly suggestive of a positive marine reserve effect.

The *L. griseus* size-structure differences that we observed are important given the results of previous studies on the recreational fisheries in ENP, BNP, and the adjacent reef tract. Rutherford et al. (1989a) analyzed 1974–84 sport landings data of *L. griseus* in ENP. Their yield-per-recruit analysis suggested that the species was growth-overfished

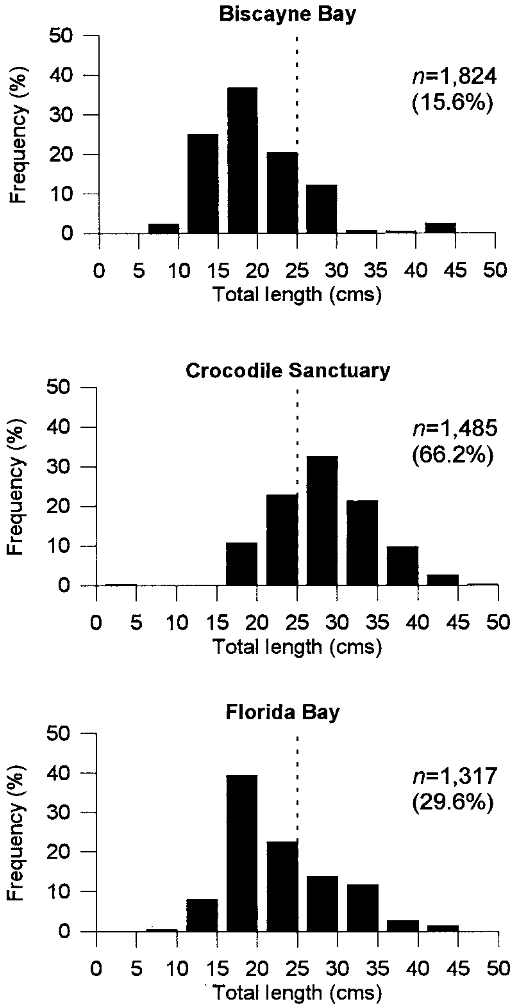

Figure 2. Length-frequency histograms for *Lutjanus griseus* observed within Biscayne Bay, Florida Bay, and the Crocodile Sanctuary of Everglades National Park. Number of individuals (*n*) and the percentage of legal-size (in parenthesis) fish are given. The dotted line denotes the 25.4 cm minimum legal size for the recreational fishery.

and they recommended the establishment of the current 25.4 cm TL minimum size limit. Harper et al. (2000) analyzed recreational fishery landings data during 1976–91 in BNP. They observed a reduction in *L. griseus* landing rates from 1984–91, but interpretation of this decline was confounded by the ‘aggregate snapper’ bag limit that was established in 1986. Six years after the enactment of the 25.4 cm TL minimum size limit, Ault et al. (1998) conducted a size-based assessment of exploited Florida Keys reef fishes. They also concluded that *L. griseus* was growth-overfished and suggested increasing the minimum size to 35 cm TL or greater.

Our study appears to be only the second example in Florida waters where a nearshore area with restricted public access, albeit for purposes other than fish stock protection, has benefited exploited species. Johnson et al. (1999) found that several fishery species in an estuarine area (adjacent to the Kennedy Space Center and closed to the public for security reasons) were more abundant and considerably larger than in fished areas nearby. For many reef-associated species, the protection of offshore spawning areas has been a major priority in the effort to prevent stock collapse (Bohnsack, 1993, 1996). However, for *L. griseus*, the protection of offshore reef habitat alone may not be enough. For this species, known locally as the 'mangrove snapper', we suggest consideration should also be given to increasing the number and size of nearshore refuges, especially those dominated by mangroves.

Though we cannot rule-out the possibility that the size distribution patterns observed in the present study reflect factors unrelated to fishing pressure, the CS-ENP is clearly a preferred habitat for larger, and presumably older and more fecund *L. griseus*. Whether the CS-ENP acts as a staging area for mature individuals to congregate prior to, or after, spawning on nearby reefs (Starck, 1971; Rutherford et al., 1989b; Pattillo et al., 1997) requires further investigation. If so, the larger *L. griseus* that we observed may represent an important component of the spawning stock that sustains population levels and mitigates local and/or regional overfishing. Based on our data, it would seem prudent for the CS-ENP to remain a restricted-access, 'no-take' area for the sake of both crocodiles and fishes. Furthermore, as one of the few mangrove-dominated areas in the U.S. that is protected from fishing and other human activities, the CS-ENP also provides a rare opportunity to learn about the structure and function of a mangrove community operating under more natural conditions. Further research into the abundance, movement, and home range of *L. griseus* and other species that utilize the CS-ENP is recommended.

Acknowledgments

We are grateful for financial support provided by the U.S. Army Corps of Engineers, the Perry Institute for Marine Science and the University of Miami's Rosenstiel School of Marine and Atmospheric Science. J. Bohnsack, B. Loftus, C. McIvor and J. Trexler greatly improved earlier drafts of this manuscript. Technical support from G. Diaz and Captain M. South greatly assisted our efforts.

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Date Submitted: September 29, 2000. Date Accepted: July 9, 2001.

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